Disaster Modeling: Medication Resources Required for Disaster Team Response

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Keywords: disaster medical assistance team (DMAT); disaster medicine; disaster modeling; disaster resources; disaster team; emergency department; medication utilization; modeling; National Disaster Medical System (NDMS)

Abbreviations:
DMAT = disaster medical assistance team
ED = emergency department
NDMS = National Disaster Medical System

Received: 11 February 2005
Accepted: 20 March 2005
Revised: 03 May 2005

Web publication: 23 August 2005

Abstract

Introduction: Responses to disasters involve many factors beyond personnel, such as medical and non-medical equipment and supplies. When disaster teams respond, they must do so with sufficient amounts of medicine and supplies to manage all of the patients expected for several days before re-supply. In order for this process to be efficient and expedient, accurate and advanced planning for supplies needed by disaster workers is necessary. These supplies must provide for general medical care and for hazard-specific problems.

Objective: To develop a model that provides the framework for determining supply requirements for the National Disaster Medical System, Disaster Medical Assistance Teams, or other responding disaster teams in a civilian environment.

Methods: A community hospital was modeled to determine patient characteristics when presenting to an emergency department (ED), including patient demographics and chief complaint, medications administered during the ED visit and prescribed at discharge, and laboratory tests ordered to assess disaster team supply requirements. Data were downloaded from a patient tracking software package and abstracted from various hospital data information systems. Data from the community hospital were compared with data published from two hurricane disasters by members of the National Disaster Medical System.

Results: To the extent possible, the model predicted the proportion of patient complaints and, therefore, the medicine and supplies needed for the management of these patients.

Conclusion: This model offers a first step in preparing disaster medical teams for deployment.

Rosenthal MS, Klein K, Cowling K, Grzybowski M, Dunne R: Disaster modeling: Medication resources required for disaster team response. ***Prehosp Disast Med*** **2005;20(5):309–315.**

Introduction

A successful disaster response is multi-factorial. Whether the response is local or national, many issues must be addressed to provide care to the affected persons or region including the type of medical system responding to the disaster. A deployed team, for example, will respond differently than will an emergency department (ED) or hospital. The purpose of a deployed team can vary significantly, ranging from an outreach facility providing replacement medications to functioning as a full-scale ED. The [US] federal government, for example, has developed the National Disaster Medical System (NDMS) and Disaster Medical Assistance Teams (DMATs) to provide medical care both during and after a significant crisis. The supply needs of these missions also vary significantly. Nonetheless, a team prepared for disaster response must have a medicine and supply cache adequate to respond to a worst-case scenario, such as when the team is functioning as a community ED with observation capabilities, as well as providing outpatient pharmacy services.

These civilian response teams may respond to a variety of situations in which the medical needs of a community can be highly varied; the military, though, has experience in medical mobilization. It has the ability to create a mobile hospital, move supplies, and provide advanced levels of care. However, its efforts are directed to a younger, healthier population involved in hostile action rather than the usual victims of a disaster.[1,2] Consequently, mobilized military medical teams may be prepared better for traumatically injured victims than would mobilization of a civilian team.

Both for local teams and the NDMS system, the medications, supplies, and amount of each chosen are provided, based on the consensus of internal committees. In addition, there has not been a published record of the requirements of an ED for medications and supplies used, procedures performed, or discharge medications prescribed. Without these data, it is difficult to optimize a team's cache of medication and supplies. This, coupled with the unpredictability associated with disasters, makes it difficult for teams to be prepared to provide the best possible care.

Some basic ED patient characteristics have been published. For example, EDs generally know patient priorities and admission rates as part of their standard quality assurance and quality control measures.[3–6] However, the possible distribution of chief complaints has been reported in the context of ED monitoring for bioterrorism, but has not been applied to disaster requirements and preparation.[7,8]

The objective of this cross-sectional study was to develop a model that will help anticipate the medications, supplies, and quantities needed to effectively and efficiently treat patients at the community level. The model developed was compared to previously published disaster responses to two hurricanes (Hurricanes Andrew and Allison) in order to compare the rates of chief complaints and laboratory use. Most disasters have occurred in a community setting; therefore, a community hospital offers a more appropriate model than does an academic medical center or inner-city facility.

Methods

To develop the model, data were collected from a community hospital in Michigan. This community hospital has an annual census of approximately 71,000 patients. It is a full-service facility with all specialties represented, except for burn care. An emergency medicine residency is present and approximately 20% of the patient population is pediatric. All aspects of this study received an Institutional Review Board exemption from both Wayne State University and Covenant HealthCare that services the community hospital, since data only were collected in aggregate form.

Different sources were used to assess the data acquired. Data were obtained for the period from 01 July 2002–30 June 2003. First, the Logicare Patient Tracking System®, Version 5 (Logicare Corporation, Eau Claire, WI) was used to obtain data from the Michigan hospital. Logicare® is a patient-tracking software package that provides patient registration, demographics, and discharge instructions, and links to both laboratory and radiology systems. In addition, all actions performed within the system are archived allowing retrieval of aggregates of data for any specific time period.

The Logicare® System was used to abstract the following data: (1) patient age; (2) chief complaint; (3) triage priority; (4) discharge medications; (5) laboratory tests procured; and (6) final ED discharge diagnosis (Table 1). Chief complaints were abstracted from Logicare® and grouped by organ system. The system's design allowed only one chief complaint to be recorded. Discharge diagnoses were abstracted from the discharge instructions. A patient can have multiple diagnoses; therefore, the total number of discharge diagnoses is greater than the number of patients discharged. Medication use was determined from medications billed to the ED by the pharmacy.

- Age
- Arrival priority
- Chief complaints
- Discharge diagnoses
- Discharge medication prescribed
- Emergency department medications/utilizations
- Radiology procedures
- Laboratory tests

Table 1—Information abstracted from the hospital's Logicare® systems

The extracted summary data were downloaded into a Microsoft Excel 2002 spreadsheet (Microsoft Corporation, Redmond, CA) and PSI-Plot, Version 9.1 (Plotting Software, Version Poly Software International, Sandy, UT) for analysis. Statistics were computed using SAS® Version 9 (SAS Institute, Cary, NC). Statistics were based on intent to treat.

Excel was used to group chief complaints, ED medications, and discharge medications into standard categories. Standard chief complaint categories included cardiac, gastro-intestinal, eye, and viral complaints, whereas, standard medication categories included antibiotics, non-narcotic pain medications, and narcotic pain medications. The grouped data then were normalized for ED census as a percent of the patient population. Using the normalized data, expected patient population characteristics and medication, laboratory, and X-ray utilization rates were estimated assuming a patient census of 750 patients over three days. The patient census was determined by the NDMS, which expects a DMAT to see 750 patients during the first three days of deployment.

Results

The age distribution of patients was weighted heavily to the very young, followed by young adults, and those in their early forties (Figure 1). After age 45 years, ED utilization rates decreased precipitously until the early 60s, maintained a plateau until the early 80s, and then markedly decreased. Figure 2 illustrates the distribution of ED visits by chief complaint. Complaints related to viral infections, abdominal maladies, traumatic injuries, and other organ systems were the most common. Among all medications used during ED visits, antibiotics, opiates, and non-steroidal, anti-inflammatory drugs were used most frequently (Figure 3).

Table 2 lists typical medications used in the ED, including pain medications and antibiotics. Table 3 lists typical discharge medications prescribed from the community ED. Interestingly, morphine was the most frequently adminis-

Medication (dosage/form)	Total doses	Doses per patient	Doses estimated for 3 days
Amoxicillin (250 mg/cap)	431	0.0061	5
Atropine syringe (1 mg/10 ml inj)	261	0.0037	3
Azithromycin (250 mg/tab)	2,098	0.0295	22
Bicillin LA (1.2 MU/2 ml inj)	89	0.0013	1
Carbamazepine (200 mg/tab)	50	0.0007	1
Cefazolin (1 gm/vial inj)	751	0.0106	8
Ceftriaxone (1 gm/vial inj)	2,431	0.0342	27
Cephalexin (250 mg/cap)	981	0.0138	10
Clonidine (0.1 mg/tab)	593	0.0084	6
Diazepam (5 mg/tab)	605	0.0085	6
Diltiazem (25 mg/5 ml inj)	1,327	0.0187	14
Diphenhydramine (50 mg/ml inj)	802	0.0113	8
Famotidine (20 mg/2 ml inj)	841	0.0118	9
Furosemide (40 mg/4 ml inj)	786	0.0111	8
Hydromorphone (2 mg/ml inj)	4,718	0.0665	50
Ibuprofen (400 mg/tab)	1,672	0.0235	18
Ibuprofen (600 mg/tab)	1,447	0.0204	15
Ketorolac (30 mg/1 ml inj)	2,561	0.0361	27
Levofloxacin in D5W (500 mg/100 ml inj)	914	0.0129	10
Lorazepam (2 mg/ml inj)	1,608	0.0226	17
Magnesium Sulfate (25 gm/50 ml inj)	517	0.0073	5
Methylprednisolone (125 mg/2 ml)	1,788	0.0252	19
Morphine (4 mg/ml inj)	6,597	0.0929	70
Phenytoin (250 mg/5 ml inj)	786	0.0111	8
Prednisone (20 mg/tab)	1,295	0.0182	14
Promethazine (25 mg/ml inj)	5,479	0.0772	58
Zosyn (3.375 gm/vial inj)	226	0.0032	2

Table 2—Sample of in-emergency department medication used from July 2002–June 2003 (Patient volume was 71,000; cap = capsule; inj = injection; tab = tablet; MU = million units; DSW = 5% Dextrose in water)

tered drug (6,597 doses), followed by Promethazine (5,479 doses). Ketorolac (2,561 doses), Cefazolin (2,431 doses), and azithromycin (2,098 doses) were the next most frequently prescribed medications. Carbamazepine (50 doses), Bicillin (89 doses), and Zosyn (226 doses) were the least frequently prescribed (Table 2). The supplies of these agents required to last three days in a field ED are compiled accordingly. The average amount of medications per patient was computed and normalized to 750 patients to determine a 3-day or 750 patient supplies needed as listed in Table 3. Ibuprofen compounds are the most frequently administered at discharge with antibiotics ranking a distant second (54 prescriptions combined.)

Medication (dosage)	Estimated number of prescriptions
Amoxicillin (500 mg)	21
Cephalexin (250 mg)	16
Azithromycin (250 mg)	13
Levofloxacin (500 mg)	4
Carbamazepine (200 mg)	1
Phenytoin (250 mg)	1
Ibuprofen (600 mg)	60
Prednisone (20 mg)	9
Promethazine (25 mg pr)	9
Diazepam (5 mg)	8
Famotidine (20 mg)	5
Clonidine (0.1 mg)	1

Table 3—Sample of estimated outpatient prescriptions to be filled by a disaster medical assistance team (DMAT) (750 patients over three days)

The results obtained using the model were compared to data published by the New Mexico DMAT.[9] The data reported by the DMAT are from its response to two hurricanes (Andrew and Allison). The data generated by this model generally agree with the DMAT's usage patterns (Table 4). The point estimates and standard deviations for chief complaints, discharge diagnosis, laboratory tests performed, treatments administered, and assigned triage category for the community hospital and victims of two hurricanes as reported by Nufer *et al* are listed in Table 4.[9] Patients of both hurricanes were more likely to have chief complaints regarding musculoskeletal pain and rashes, and less likely to complain of symptoms associated with urinary tract infections, compared with community ED patients. The hurricane patients also were more likely to be diagnosed for wounds and needing prescription refills when compared with community ED patients, but less likely to have radiographs ordered. Compared to community ED patients, patients of Hurricane Andrew were less likely to have complete blood counts and chemistry studies ordered. Patients in both hurricanes, however, were more likely to

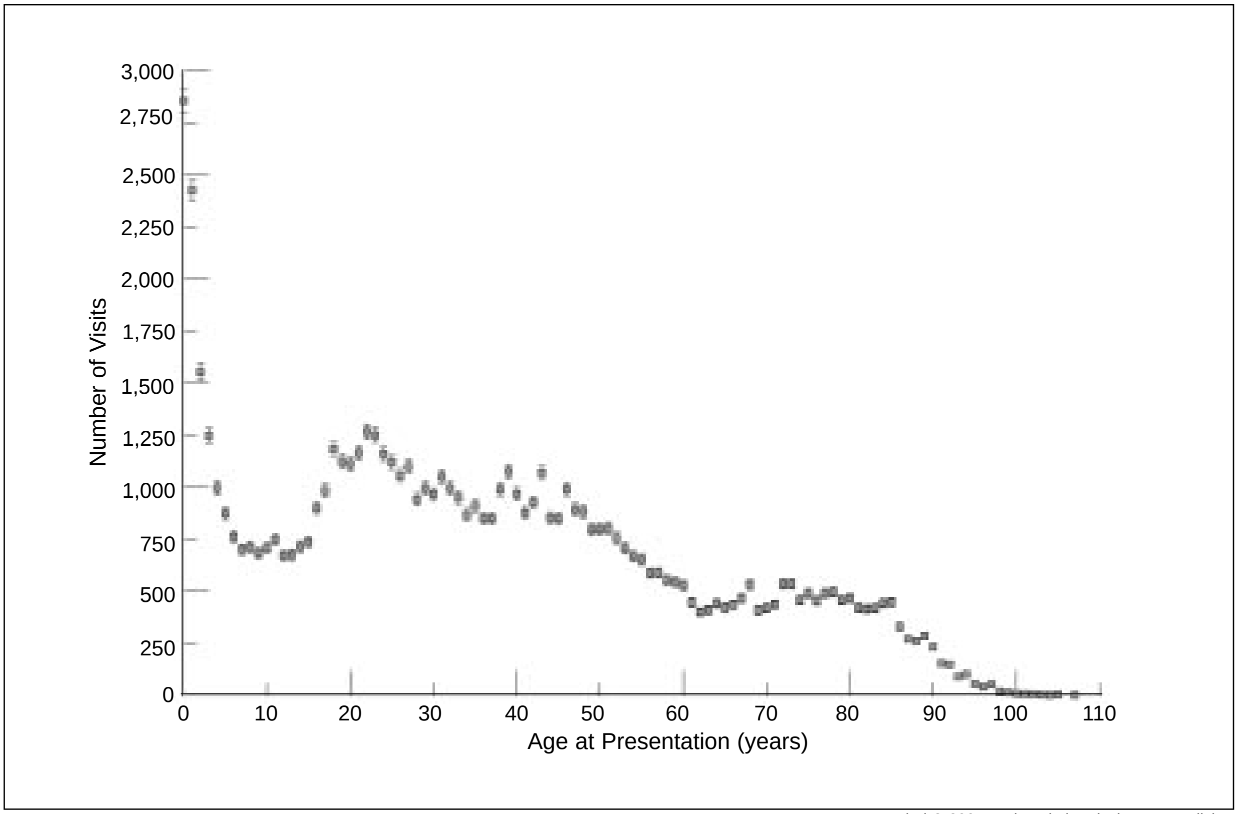

Figure 1—Number of vists by age (years) from July 2002-June 2003

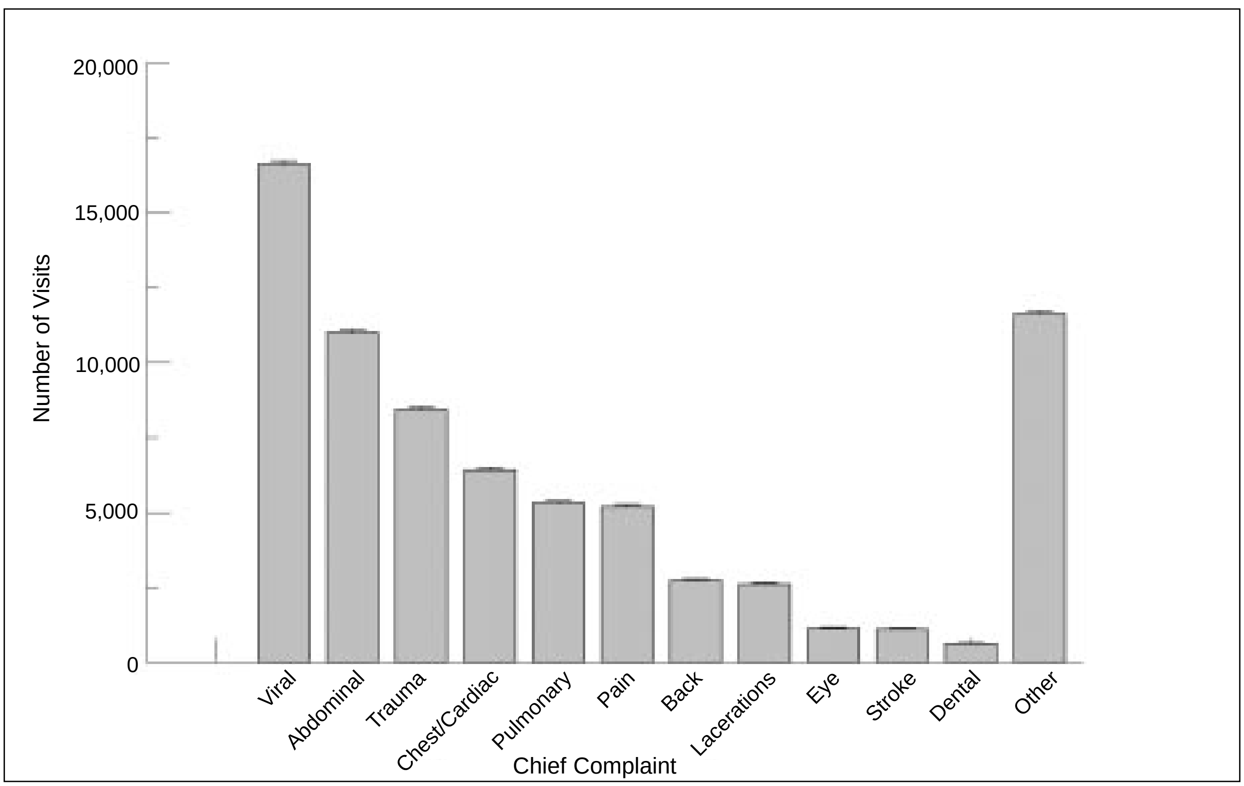

Figure 2—Number of visits by chief complaint

Chief Complaints	Community Hospital	Hurricane Andrew	Odds Ratio (95% CI)	Hurricane Allison	Odds Ratio (95% CI)
Wounds	16.0 ±0.1	23.7 ±3.1	1.6 (1.4–1.9)	17.0 ±3.1	1.1 (0.9–1.3)
Musculoskeletal Pain	7.0 ±0.1	13.7 ±2.5	22.4 (18.1–27.8)	12.8 ±2.7	21.0 (16.1–27.2)
Upper Respiratory Infection	23.0 ±0.2	9.0 ±2.1	0.3 (0.3–0.4)	19.0 ±3.2	0.8 (0.6–1.0)
Rash	1.0 ±<0.1	6.9 ±1.9	7.3 (5.6–9.6)	7.3 ±2.1	7.7 (5.6–10.7)
Abdominal Complaint	15.0 ±0.1	5.8 ±1.7	0.34 (0.3–0.5)	5.5 ±1.9	0.3 (0.2–0.5)
Diagnoses Recorded for Visit					
Wounds	4.0 ±0.1	19.5 ±2.9	5.8 (4.9–6.9)	19.4 ±3.2	5.8 (4.7–7.1)
Medication Refill	1.0 ±<0.1	13.2 ±2.5	15.0 (12.1–18.6)	3.7 ±1.5	3.8 (2.4–5.9)
Musculoskeletal Pain	9.0 ±0.1	8.6 ±2.1	0.9 (0.7–1.2)	9.6 ±2.4	1.1 (0.8–1.4)
Insect Bite	1.0 ±<0.1	0		9.4 ±2.4	10.2 (7.6–13.7)
Cellulitis	1.0 ±<0.1	0		5.0 ±1.8	4.7 (3.2–6.9)
Otitis Media	2.0 ±<0.1	2.6 ±2.6	1.3 (0.8–2.0)	5.0 ±1.8	2.5 (1.7–3.7)
Laboratory Testing Performed					
Urinary Analysis	26.3 ±0.2	22.8 ±5.6	0.8 (0.7–1.0)	22.9 ±14.0	0.8 (0.7–1.0)
X-ray	38.0 ±0.2	22.3 ±5.6	0.5 (0.4–0.6)	20.0 ±13.3	0.4 (0.3–0.5)
Glucometer		17.2 ±5.0		48.6 ±16.6	
Complete Blood Count	43.9 ±0.2	12.1 ±4.4	0.2 (0.1–0.2)	0	
Chem 7	29.3 ±0.2	7.0 ±3.4	0.2 (0.1–0.2)	0	
Treatment Given					
Wound Care	4.0 ±0.1	15.8 ±2.5	4.5 (3.7–5.4)	11.6 ±2.6	3.2 (2.4–4.1)
Antibiotics	16.0 ±0.1	15.5 ±2.4	1.0 (0.8–1.2)	16.6 ±3.1	1.0 (0.8–1.3)
Pain Medications	29.0 ±0.2	10.6 ±2.1	0.3 (0.2–0.4)	13.6 ±2.8	0.4 (0.3–0,5)
Benadryl	1.6 ±<0.1	2.2 ±1.0	1.4 (0.9–2.2)	0.2 ±0.2	0.1 (0.0–0.8)
Triage Category					
Priority 3	85.0 ±0.3	61.2 ±3.6	0.3 (0.2–0.3)	79.3 ±3.3	0.7 (0.6–0.8)
Priority 2	14.0 ±0.1	17.7 ±2.8	1.3 (1.1–1.6)	15.1 ±2.9	1.1 (0.9–1.4)
Priority 1	1.0 ±<0.1	4.2 ±1.5	5.3 (3.7–7.4)	2.5 ±1.3	2.5 (1.5–4.3)

Table 4—Comparison of hurricane presentations versus a community hospital ED patient presentations (Comparison of a community hospital with a DMAT's response to two hurricanes; Data presented as percent of total number of patients seen; odds ratio comparison of each hurricane to the community hospital; ED = emergency department; CI = confidence interval)

receive wound-care medications and less likely to receive pain medications. Lastly, patients of both hurricanes were more likely to be triaged as Priority 1, but less likely to be triaged as Priority 3.

Of the chief complaints reported by the DMAT, for example, approximately 20% were for wounds and 13% for musculoskeletal pain. The community hospital's chief complaint rates for wounds were 16% and 7% for musculoskeletal pain. There also are differences between the two hurricanes and the model prediction. In the categories reported by Nufer *et al*,[9] however, the differences between the current model and the hurricane results are small, except for differences in the rates of wound care.

The wound data have a higher odds ratio for diagnosis compared to the chief complaint data and probably represents some increased wounds suffered by patients in the

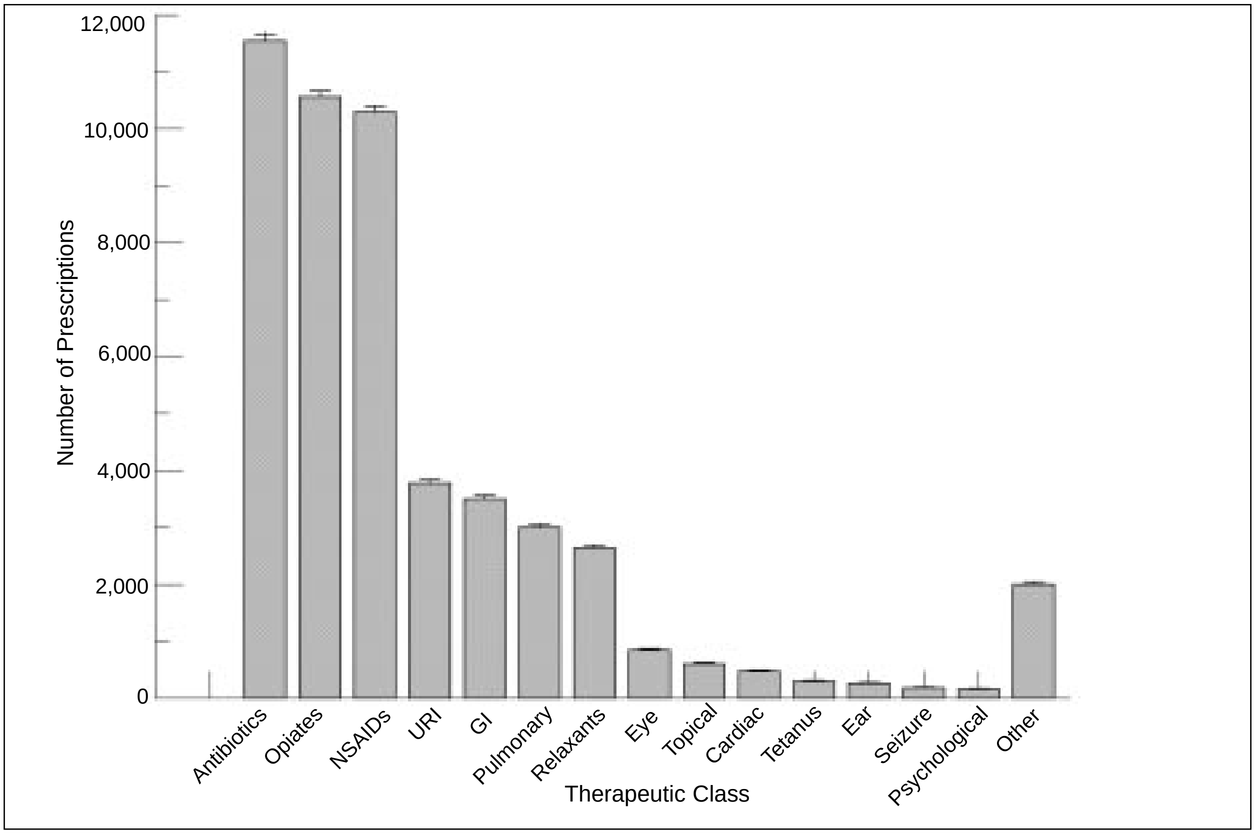

Figure 3—Number of prescriptions by therapeutic class (GI = gastrointestinal; URI = upper respiratory infection; NSAIDs = Non-steroidal anti-inflammatory drugs)

hurricane-affected areas. However, Nufer *et al* also noted the differences between the two hurricanes. Thus, as shown by the hurricane data, the rates of chief complaints, diagnoses, laboratory tests performed, treatment provided, and triage categories for similar events can vary significantly.

Discussion

The data demonstrate the utilization of resources within a community ED. While the facility does not operate in a disaster mode, most disasters teams also will not operate in a "disaster mode". A disaster response has two components. The first component is the time immediately after the event. Local facilities will need to care for people displaced and/or injured by the event. Local facilities also will need to treat people injured in the event and the basic emergency department population. If no major damage occurs, the facilities will enter a disaster mode, but utilize the resources they have on a daily basis. The results of this investigation do not help in this type of scenario.

The second component to a disaster response is the deployment of teams from outside the area or from facilities within the affected area. In most cases, these teams will start to provide care within 24 hours of the event. Acutely injured persons will have been transported to existing emergency departments and been treated. The incoming teams most likely will treat late injuries and illnesses in the population recovering from the event. This population can be expected to present a typical distribution of complaints for an ED, with an increase in injuries and wounds from the recovery effort.[10]

Based on this scenario, it would be logical to model a community ED to develop a medication and supply cache for a response team to be able to provide care in a worst-case scenario. Again, as the response teams generally arrive within 24 hours of an event, they would be expected to see the typical patient population with a potential increase in minor trauma (e.g., lacerations and fractures) from recovery efforts and increased medication refill requests. This model attempts to provide the data to guide the supplies for response teams for such a mission.

Generally, EDs have a broad selection of medications and supplies to provide care to patients and satisfy the choices of its medical providers. Prior to an event, however, medical providers' choices are unknown and storing and inventorying a broad selection of medications and supplies is complex. Therefore, teams should utilize medication and supply data to reduce the choices available, but keep the total number of doses or total supplies constant. A reduced selection of medications still should cover any condition and expected patient, but instead of offering 10 choices of cephalosporin antibiotics, for example, only offer two or three. Choices should be broader in coverage and applicability both for in-patient and outpatient use. In addition, the use of medications should be increased from a standard

ED model to provide medication refills and medication replacement for those involved in the event.

The community-ED data reasonably model the hurricane data, therefore, they can be used to help predict medication and supply needs for a disaster team response.

Limitations

This model provides a first attempt in creating medication lists for disaster teams. Medicine and supply needs will vary from region to region and the data presented represent only one community hospital in one area. Some of the regional variations will depend on local antibiotic resistance patterns and differences in the type of chief complaints presented. For example, in the United States, spider bites, snake bites, and heat-related injuries will occur more frequently in the south than in the north, where more cold-related injuries will occur.

The model assumes the expected patient population following an event will be typical for a region. The data indicate that this is a reasonable expectation.[9] The medication utilization data, however, most likely will contain some errors because medications that were drawn up and charged were reported as utilized medications without knowing if they were used.

Finally, although this is a model of a community ED with predicted rates of events reported, the actual individual complaints or events seen in a three-day period could be much higher or lower than predicted, which further complicates determinations of supplies. Variations in needs will be based on the actual problems experienced by the local population and by which medications must be replaced for the population at risk. This is evident in the data between the two hurricanes reported by Nufer *et al*.[9] However, the modeling of a community emergency department provides a scientific basis for determining needs.

Conclusion

This investigation offers the first model of a community ED based on medication utilization. The model can be used to guide the development of a medication and supply cache adequate for responding to a worst-case scenario. The resulting medication and supply cache will derive from expected patient complaints not on consensus opinion.

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